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GROWTH RESPONSE OF *Vitellaria paradoxa* C.F Gaertn SEEDLINGS TO LEAF LITTERS OF SELECTED NITROGEN FIXING ACACIA TREES

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ABSTRACT

The dearth of quantified information on the growth response of *Vitellaria paradoxa* seedlings to plant based organic manure has limited its propagation. In an attempt to enhance the slow growth of *V.paradoxa*, research was carried out to assess the growth response of *V. paradoxa* seedlings to leaf litters of selected nitrogen fixing acacia trees.The experiment adopteda Completely Randomized Design with seven treatments replicated five times. The treatments consisted of 200g each of leaf litters of selected nitrogen fixing acacia trees (*Acacia tortilis*, *Acacia senegal*, *Acacia nilotica*, *Acacia seyal*, *Acacia leucophloea* and *Acacia albida*) and control on the growth of *V. paradoxa*. A total of thirty five (35) seedlings were involved in the experiment. A-year old *V. paradoxa* seedlings planted in the soil in the pot with and without manure was subjected to 200ml of water twice daily. Growth parameters evaluated include height, girth, number of leaves, leaf area, leaf area index, fresh and dry weight. Data collected were subjected to Analysis of Variance (ANOVA)at 5% level of probability. Leaf litters of selected nitrogen fixing acacia trees significantly enhanced the growth response of *V. paradoxa* seedlings. Highest height (44.20cm)., girth (4.16cm)., number of leaves (16.8)., leaf area (147.07cm^2).,leaf area index (1.53)., total fresh weight (20g)., total dry weight (11.95g) were recorded from seedlings planted in the soil enhanced with *A. leucophloea*. Highest nitrogen (3.6%) and phosphorus (458mg/100g) were recorded from leaf litters of *A. leucophloea*. Planting of *V. paradoxa* in the soil influenced with leaf litters of *A. leucophloea* enhanced its seedling growth.

Keywords: Manure, Nitrogen fixing trees, Growth, Leaflitters, Soil amendment.

Introduction

Tropical forests contain many socio-economically important tree species, most of which are currently endangered and with edible parts (Liao *et al.*, 2006).Some of these species are threatened based on World Conservation Union Classification. The shea tree, *Vitellaria paradoxa* is one of such threatened and priority fruit trees (Byakagaba *et al.*, 2011, AbdulRahaman *et al.*, 2016).The *Vitellaria paradoxa* is an indigenous fruit tree of Sudano - Sahelian African which belongs to the family Sapotaceae (Okullo*et al.*, 2004a, b). Its natural habitat stretches over Africa south of the savannah, from the Eastern part of Senegal to the North of Uganda. It is called Monkade, kareje, Chammal, Orioyo, Okeruma and Kirite in Hausa, Fulani, Tiv, Yoruba, Igbo and French respectively (Adeoye, 2011).

The *V. paradoxa* tree has diverse potentials. The West African annual production of its nut in years of good crops is estimated at about 600,000 metric tons of dry nuts, while Nigeria accounts for 50% of its production (Adeoye, 2011). Adeoye (2011) reported that the Nigeria production level was 373,000 metric tons for its dry nuts in 1991. The pulp of the *V. paradoxa* fruit is a rich source of some micro nutrients including ascorbic acid (196.1mg/100g), in comparison with an orange, which contains only 50mg/100g. The *V. paradoxa* nuts contain 1.93mg/100g of iron and 36.4mg/100g of calcium. The pulp contains vitamin B and 3 to 6 percent of high sugar that made up of glucose, fructose and sucrose equally (Teketay*et al.,* 2003; Maanikuu and Peker, 2017).

The roots of the *V. paradoxa*tree alone are used by locals in Northern Nigeria as chewing sticks for cleaning the teeth and equally used to produce poison among the Jukun ethnic tribe in Northern Nigeria when mixed with tobacco (Teketay *et al.,* 2003; Maanikuu and Peker, 2017).

Maanikuu and Peker (2017) stated that the *V. paradoxa*roots are also combined in mixture with the bark in traditional medicine for the treatment of jaundice, diarrhoea and stomach pain. The root bark is boiled and pounded and used for treating chronic sores in horses (Teketay*et al.,* 2003;Maanikuu and Peker, 2017).The *V. paradoxa* tree produces latex which can be mixed with palm oil to produce glue (Agyekwena, 2011). Agyekwena (2011) stated that the shell or husks of the *V. paradoxa*nut is used in the purification of water from heavy metals.

The *V. paradoxa* butter is an anti-ageing, good sun screening agent and it contains vitamins A and E, which makes it a good moisturizer for hair (Nahm, 2011; Maanikuu and Peker, 2017) and Vitamin F which has the ability to act as a rejuvenator for soothing, healing rough and chapped skin (Malachi, 2013). It is widely used to lower cholesterol and protection of hair against the harmful free radicals in the air, water and harsh weather conditions (Masters *et al.*, 2004; Maanikuu and Peker, 2017).As a deciduous woody perennial species, *V. paradoxa*plays a major role in nutrients restoration through the decay of its leaves and fine roots on the soil surface (Bayala*et al.*, 2005).

To continue to enjoy enormous potentials of *V.paradoxa*, its slow growth which is a threat to its regeneration needs to be addressed through the use of fertilizer.Rachel (2015) stated that fertilizers boost the soil's reserves of elements essential to the healthy growth and development of plants.Akinnifesi*et al.* (2007) reported that inadequate supply due to delivery problems and prohibitive costs have been affecting the use of inorganic fertilizers by small holder farmers. Excessive chemical fertilizer contaminates the environment (Olowe and Akintunde, 2012). The insufficiency, bulkiness, offensive odour, disease outbreak as well as increased incidence of weeds have limited the use of animal manure (Adekola and Usman, 2009; Emeghara*et al.*, 2012). The use of biomass transfer method which is an agroforestry practice is a viable option to overcome these challenges.

Schroth and Sinclair (2003) stated that biomass transfer system represent an intermediate situation in which the nutrients in the biomass are removed from one site and added to another site within the same landscape for soil fertility restoration. Litters of nitrogen fixing trees are rich in nutrients which are essential for enhancing the fertility of soil as well as to increase crop productivity(Schroth and Sinclair, 2003) without jeopardizing environment. There is paucity of quantified information on the growth response of*V.paradoxa* to leaf litters of nitrogen fixing acacia trees. In this light, this investigation was conducted to assess the growth response of *V. paradoxa* to leaf litters of selected nitrogen fixing acacia trees.

Materials and Method

Experimental site

The research was conducted in the screen house of Federal College Forestry Mechanization, Afaka, Kaduna. The College is located in the Northern Guinea Savannah ecological zones of Nigeria. It is situated in Igabi Local Government Area of Kaduna State, Nigeria. It lies between Latitude $10^{o}35'$and $10^{o}34'$and Longitude $7^{o}21'$and $7^{o}20'$(Adelani, 2015). The mean annual rainfallis approximately 1000mm. The vegetation isopen woodland with tall broad leave trees (Otegbeye*et al.*, 2001).

Experimental Materials

The fruits were collected from mother tree in Niger State. The seeds wereextracted, washed andair dried for 30 minutes. The biomass transfer method which involved the collection of wet leaves of nitrogen fixing trees from different location was used. The nitrogen fixing acacia trees are not in the same location. The samples of the different leaves of nitrogen fixing acacia trees were air dried and pulverized. The river sand wascollected from the floor of the College dam and sieved through 2mm sieve. The sieved sand was sterilized at 160°C for 24hours.

Data collection

The experimental design adopted for the growth response *Vitellariaparadoxa*seedlingsto leaf litters ofselected nitrogen fixing acacia trees (*Acacia tortilis*, *Acacia senegal*, *Acacia nilotica*, *Acacia seyal*, *Acacia leucophloea*, *Acacia albida*)andcontrolwasa Completely RandomizedDesign with five replicates. The experiment involved a total of thirty five (35) seedlings which consisted of seven treatments. A seedlingrepresented a replicate. A-year old seedling wastransplanted into a potting mixture packed in larger poly pots of $25x20x15cm^3$dimensions. The potting mixturecontained samples of sterilized sand thoroughly mixed with each leaves of nitrogen fixing acacia trees at same quantityof 200g. Each sample of pulverized leaves of nitrogen fixing trees was analyzed chemically for nitrogen, phosphorus and potassium (NPK). The sand without the addition of leaf litters was analyzed for nutrient content of soil under control treatment. The 200ml of distilled water per seedling was used to water the seedlings with and without manure twice daily.

Growth parameters were monitored every four weeks for 24 weeks.Growth parameters assessed include; Seedling height (using meter rule); girth (using venier caliper); the number of leaves were counted manually while the leaf area was obtained by linear measurement of leaf length and leaf width as described by Clifton-Brown and Lewandowski (2000).

LA = 0.74xLxW [1]

Where, LA = leaf Area = Product of linear dimension of the length and width at the broadest part of the leaf.

Leaf Area Index was calculated by using the formula: leaf area/land area.

The fresh and dry weights were determined by the use Mettler Top Loading Weighing Balance, but dry weight was taken after oven dried the seedlings at 70°C for 72 hours (Umar and Gwaram, 2006).

Data analysis

The data on the growth response of *Vitellaria paradoxa* seedlings to leaf litters of selected nitrogen fixing acacia trees were subjected to one way analysis of variance (ANOVA) using SAS (2003).Comparison of significant means was accomplished using Fishers Least Significant Difference (LSD) at 5% level of significance.

Results

Growth response of *V. paradoxa* height to leaf litters of selected nitrogen fixing acacia trees

Highest height of 44.20cm was recorded from seedlings planted in soil influenced with leaf litters of *A. leucophloea*., while the least value of 6.0cm was recorded from seedlings planted in the soil without amendment with leaf litters of nitrogen fixing acacia (control)at 24 and 4 weeks after transplanting, WAT respectively (Table 1).

Table 1: Growth response of *V. paradoxa* height (cm) to leaf litters of selected nitrogen fixing acacia trees

NFAT		Weeks	After	Transplanting		
	4	8	12	16	20	24
A. tortilis	10.90[a]	12.64[a]	13.74[a]	14.86[a]	15.60[a]	16.44[a]
A. senegal	7.60[b]	10.60[b]	14.76[ab]	18.00[a]	19.24[a]	20.50[a]
A. nilotica	8.94[b]	10.60[ab]	14.66[ab]	15.40[ab]	16.40[a]	17.40[a]
A. seyal	7.62[b]	12.26[ab]	13.80[ab]	17.32[a]	18.50[a]	19.22[a]
A.leucophloea	8.70[d]	10.92[d]	18.60[c]	30.10[b]	42.00[a]	44.20[a]
A. albida	8.36[c]	12.90[c]	20.12[b]	26.64[b]	29.02[a]	31.12[a]
Control	6.00[a]	7.72[a]	8.54[a]	9.98[a]	10.24[a]	10.42[a]
SE±	2.66	2.86	2.90	2.94	3.01	3.00

*Means on the same rows with the same alphabet are not significantly different at ($P<0.05$)

Key: NFAT=Nitrogen Fixing Acacia Trees

WAT= Weeks After Transplanting

Growth response of *V. paradoxa* girth to leaf litters of selected nitrogen fixing acacia trees

Highest girth of 4.16cm was recorded from seedlings planted in the soil enhanced with leaf litters of *A. leucophloea*., while the least value of 0.72cm was recorded from seedlings planted in the soil not influenced with leaf litters of nitrogen fixing acacia trees (control) at 24 and 4 WAT respectively (Table 2).

Table 2: Growth response of *V. paradoxa* girth (cm) to leaf litters of selected nitrogen fixing acacia trees

NFAT		Weeks	After	Transplanting		
	4	8	12	16	20	24
A.tortilis	1.42[b]	1.54[ab]	1.72[ab]	1.90[ab]	1.92[ab]	2.06[a]
A.senegal	1.60[b]	1.70[b]	1.96[ab]	2.24[ab]	2.28[a]	2.40[a]
A.nilotica	1.88[b]	2.02[b]	2.26[ab]	2.40[ab]	2.54[ab]	2.66[a]
A.seyal	1.34[b]	1.47[b]	1.66[ab]	1.82[ab]	1.84[ab]	2.04[a]

A.leucophloea	1.72[c]	3.00[b]	3.24[ab]	3.72[a]	3.92[a]	4.16[a]
A.albida	1.22[b]	2.52[a]	2.56[a]	2.76[a]	2.76[a]	2.80[a]
Control	0.72[a]	0.88[a]	0.92[a]	0.92[a]	0.96[a]	0.96[a]
SE±	0.22	0.23	0.24	0.23	0.23	0.25

*Means on the same rows with the same alphabet are not significantly different at (P<0.05)

Key: NFAT=Nitrogen Fixing Acacia Trees
WAT= Weeks After Transplanting

Growth response of *V. paradoxa* number of leaves to leaf litters of selected nitrogen fixing acacia trees

Highest number of leaves of 16.8 was recorded from seedlings planted in the soil enhanced with *A. leucophloea* leaf litters, while the least value of 2.60 was recorded from seedlings planted in soil not enhanced with leaf litters of nitrogen fixing acacia trees(control)at 24 and 4 WAT respectively (Table 3).

Table 3: Growth response of *V. paradoxa* number of leaves to leaf litters of selected nitrogen fixing acacia trees

NFAT		Weeks	After	Transplanting		
	4	8	12	16	20	24
A.tortilis	5.40[b]	6.00[b]	6.60[b]	7.40[b]	8.40[a]	10.00[a]
A.senegal	6.20[b]	6.60[b]	7.20[b]	7.60[b]	8.40[b]	12.13[a]
A.nilotica	6.36[b]	7.32[b]	7.70[b]	8.30[ab]	9.30[ab]	10.06[a]
A.seyal	5.60[b]	6.40[b]	6.40[b]	7.20[ab]	8.20[ab]	9.20[a]
A.leucophloea	5.80[d]	8.40[c]	10.00[bc]	12.80[b]	14.80[ab]	16.8[a]
A.albida	6.60[b]	7.20[b]	7.20[b]	8.20[ab]	9.20[ab]	9.60[a]
Control	2.60[a]	2.61[a]	3.40[a]	3.40[a]	3.40[a]	3.50[a]
SE±	0.78	0.77	0.90	0.95	1.09	1.21

*Means on the same rows with the same alphabet are not significantly different at (P<0.05)

Key: NFAT=Nitrogen Fixing Acacia Trees
WAT= Weeks After Transplanting

Growth response of *V. paradoxa* leaf area to leaf litters of selected nitrogen fixing acacia trees

Highest leaf area of 147.07cm^{2}was recorded from seedlings planted in the soil enhanced with leaf litters of *A. leucophloea* at 24 WAT. The least value of 17.49cm^{2}was recorded from seedlings planted in the soil without amendment of leaf litters of nitrogen fixing acacia trees (control) at 8 WAT(Table 4).

Table 4: Growth response of *V. paradoxa* leaf area (cm^2) to leaflitters of selected nitrogen fixing acacia trees

NFAT		Weeks	After	Transplanting		
	4	8	12	16	20	24
A.tortilis	92.71[a]	92.29[a]	109.57[a]	119.47[a]	118.82[a]	118.95[a]

A.senegal	64.01[a]	65.43[a]	56.91[a]	61.40[a]	61.31[a]	63.67[a]
A.nilotica	62.44[a]	61.99[a]	58.20[a]	57.49[a]	60.31[a]	86.84[a]
A.seyal	39.94[a]	35.86[a]	32.93[a]	42.84[a]	47.10[a]	49.72[a]
A.leucophloea	60.43[b]	64.74[b]	78.56[b]	126.29[a]	135.87[a]	147.07[a]
A.albida	72.58[a]	77.29[a]	63.18[a]	88.01[a]	75.63[a]	81.35[a]
Control	18.30[a]	17.49[a]	21.70[a]	17.66[a]	21.27[a]	24.61[a]
SE±	9.14	11.46	12.47	11.46	19.60	14.50

*Means on the same rows with the same alphabet are not significantly different at (P<0.05)

Key: NFAT=Nitrogen Fixing Acacia Trees
WAT= Weeks After Transplanting

Growth response of *V. paradoxa* leaf area index to leaf litters of selected nitrogen fixing acacia trees

Highest leaf area index of 1.53was recorded from seedlings planted in the soil influenced with leaf litters of *A. leucophloea* at 24WAT, while the least value of 0.18was recorded from seedlings planted in the soil not enhanced with leaf litters of nitrogen fixing acacia trees (control) at 8WAT(Table 5).

Table 5: Growth response of *V.paradoxa* leaf area index to leaf litters of selected nitrogen fixing acacia trees

NFAT		Weeks	After	Transplanting		
	4	8	12	16	20	24
A.tortilis	0.96[a]	0.98[a]	1.14[a]	1.04[a]	0.96[a]	1.24[a]
A.senegal	0.66[a]	0.68[a]	0.59[a]	0.58[a]	0.45[a]	0.66[a]
A.nilotica	0.65[a]	0.65[a]	0.61[a]	0.60[a]	0.64[a]	0.91[a]
A.seyal	0.42[a]	0.37[a]	0.34[a]	0.45[a]	0.49[a]	0.64[a]
A.leucophloea	0.63[b]	0.67[b]	0.82[b]	1.31[a]	1.42[a]	1.53[a]
A.albida	0.76[a]	0.81[a]	0.66[a]	0.77[a]	0.79[a]	0.85[a]
Control	0.19[a]	0.18[a]	0.20[a]	0.21[a]	0.19[a]	0.33[a]
SE±	0.10	0.12	0.12	0.12	0.15	0.24

*Means on the same rows with the same alphabet are not significantly different at (P<0.05)

Key: NFAT=Nitrogen Fixing Acacia Trees
WAT= Weeks After Transplanting

Growth response of *V. paradoxa* fresh and dry weight to leaf litters of selected nitrogen fixing acacia trees

Highest fresh and dry root weights of 11.95g and 7.65g were recorded from seedlings planted in the soil influenced with *A. leucophloea* leaf litters. The least values of 0.20g and 0.05gwere recorded from fresh and dry leaves of seedlings planted in the soil without amendment of leaflitters of nitrogen fixing acacia trees(control) respectively. Highest total fresh weight (20g) and total dry weight (11.95g) were recorded from seedlings planted in the soil enhanced with leaflitters of *A. leucophloea*. The lowest values of total fresh weight(4.70g) and total dry weight

(2.05g) were recorded from seedlings planted in the soil not influenced with leaflitters of nitrogen fixing acacia trees (control) respectively(Table 6).

Table 6: Growth response of *V.paradoxa* fresh and dry weight (g) to leaflitters of selected nitrogen fixing acacia trees

NFAT	FW			TFW	DW			TDW
	L	S	R		L	S	R	
A.tortilis	1.90^{b}	1.45^{b}	10.45^{a}	13.80^{ab}	0.90^{b}	0.35^{c}	4.95^{a}	6.20^{b}
A.senegal	1.40^{b}	1.30^{b}	9.40^{a}	12.10^{ab}	0.60^{b}	0.45^{b}	4.90^{a}	5.95^{bc}
A.nilotica	1.25^{b}	0.90^{b}	10.50^{a}	12.65^{ab}	0.45^{b}	0.30^{b}	5.70^{a}	6.45^{b}
A.seyal	1.20^{b}	1.25^{b}	10.75^{a}	13.20^{ab}	0.50^{b}	0.50^{b}	4.80^{a}	5.80^{bc}
A.leucophloea	5.40^{b}	2.65^{b}	11.95^{a}	20.00^{a}	2.85^{b}	1.45^{b}	7.65^{a}	11.95^{a}
A.albida	1.55^{b}	0.80^{b}	7.95^{a}	10.30^{ab}	0.75^{b}	0.35^{c}	3.85^{a}	4.95^{c}
Control	0.20^{b}	0.80^{ab}	3.70^{a}	4.70^{b}	0.05^{c}	0.30^{b}	1.70^{a}	2.05^{d}
SE±	0.85	0.62	2.56	4.03	0.04	0.03	0.2	0.5

*Means on the same rows with the same alphabet are not significantly different at (P<0.05) for fresh and dry weight

*Means on the same columns with the same alphabet are not significantly different at (P<0.05) for total fresh weight and total dry weight

Key: NFAT-Nitrogen fixing acacia trees

Nutrient composition of leaf litters of selected nitrogen fixing acacia trees

Highest nitrogen (3.69%), phosphorus(458mg/100g) and potassium(22.49mg/100g) were recorded from leaf litters of *A. leucophloea*, *A.leucophloea* and *A.albida* respectively. The least values of nitrogen (0.05%), phosphorus (0.02mg/100g) and potassium(0.07mg/100g) were recorded from soil not influenced with leaflitters of selected nitrogen fixing acacia trees respectively (Table 7).

Table 7: Nutrient composition of leaf litters of selected nitrogen fixing acacia trees

NFAT	N%	P mg/100g	K mg/100g
A.seyal	3.22	353.27	21.49
A.tortilis	2.67	415.80	18.78
A.albida	2.84	380.22	22.49
A.nilotica	2.93	406.34	16.45
A.senegal	2.34	362.49	14.32
A.leucophloea	3.69	458.98	20.65
Control	0.05	0.02	0.07

Discussion

Highest growth parameters were recorded from seedlings planted in the soil enhanced with *A. leucophloea*. It could be deduced that growth recorded from seedlings planted in soil influenced with *A. leucophloea* leaf litters was as a result of its ability to release nutrient into the soil, which enriched the soil for *V.paradoxa* roots to absorb for better growth than other species investigated. This result is in consonance with reports that the leaf litters of superior tree species influence nutrient release into soil (Manlay *et al.*,2000, Diedhiou *et al.*,2009) as well as enhancing growth and yield better than others investigated species (Sarkar *et al.,* 2010).

Highest girth recorded from seedlings planted in the soil influenced with *A. leucophloea* leaf littersis in consonance with the report of Adelani *et al.* (2020a) who recorded widest girthfor *C. albidum* seedlings planted in the soil amended with leaf litters of *Acacia leucophloea* at 8 weeks after transplanting. The excellent number of leaves recorded from *V. paradoxa* planted in the soil enhanced with *A. leucophloea* leaf litters was attributed to its richness in nutrients. Similar observation has been made by Jeptoo *et al.* (2013)who reported that more leaf numbers recorded from carrot as a result of rich tithonia manure application could be ascribed to enhanced levels of major nutrients (NPK) in tithonia manure as revealed by improved nutrient levels in the soil at the end of each growing season.

Highest leaf area recorded from *V. paradoxa* planted in the soil influenced with leaflittersof *A. leucophloea* trees could be adduced to its better release of nutrient for growth of leaf area. This is consonance with the report of Adelani *et al.*(2020b) who stated that a significant leaf area recorded for *Citrus tangelo* seedlings planted in the soil influenced with *Jacaranda mimosifolia* was an indication that *Jacaranda mimosifolia* gave the seedlings appropriate nitrogen to enhance the growth parameters. Significant fresh weight and dry weight were recordedfor the *V. paradoxa* seedlings planted in the soil incorporated with leaf litters of *A. leucophloea* respectively. Similar observation has been made by Adelani *et al.*(2020a) who recorded significant fresh weight and dry weight for *C. albidum* seedlings planted in the soil influenced with leaf litters of *Acacia senegal*.

Excellent growth parameters recorded from *V. paradoxa* seedlings planted in soil amended with *A. leucophloea* leaf litters could also be traced to its ability to release nitrogen content better than other investigated species. Similar observation has been made by Gaisie *et al.* (2016) who stated that nitrogen released from *Albizia lebbeck* was significantly greater than that of *Senna siamea*. This finding is in consonance with that of Iloyanomon and Ogunlade (2011) who reported highest nitrogen release from leaf litters of *Cola nitida* under plantation A relative to others. In the same trend, Mahmood *et al.*(2009) reported that *Eucalyptus camaldulensis* leaf litters released highest nitrogen compared to other species studied.

The leaf litters of nitrogen fixing acacia tree was sources of nitrogen which influenced *V. paradoxa* seedlings growth in this study. Sinfield *et al.* (2010) stated that nitrogen is part of various enzymatic proteins that catalyses and regulates plant-growth process. It is a component of chlorophyll (Anderson, 2015). Nitrogen has been called the growth element because it is a vital part of protoplasm. Protoplasm is the seat of cell division (Abod and Siddiqui, 2002).The superior performance of *V. paradoxa* seedlings planted in the soil improved with leaf litters of *A. leucophloea* over other treatment combinations is traceable to highest phosphorus content of *A. leucophloea*. Adelani *et al.* (2017) stated that phosphorus has been reported for its enhancement of growth of tree seedlings. Phosphorus improves the germination of seeds as well as seedling growth of trees and arable crops (Mengel and Kirkby; 2001, Smith,2014; Adelani *et al.*, 2020a).Phosphorus is considered a primary nutrient for plant growth (Hinsinger, 2001) and needed to sustain optimum plant production and quality (Zapata and Zaharah, 2002). Epstein and Bloom (2004) stated that the P element is essential for cell division, reproduction, and plant metabolism; moreover, its role is related to the acquisition, storage, and use of energy.

In addition, phosphorus plays an important role in lateral root morphology (Williamson *et al.*, 2001) and root branching (Lopez-Bucio *et al.*, 2003) influencing not only root development, but also the availability of nutrients to plants (Jin *et al.*, 2005). Therefore, plants have developed various strategies for obtaining optimum P from soils, including increases in root surface area, specific root length (SRL), and root-shoot ratio (Tang *et al.*, 2009; Xu *et al.*, 2012). The growth-promoting role of P application has been reported previously (Williamson *et al.*, 2001, Pandey *et al.*,2006, Waraich *et al.*, 2015). This is in consonance with the reports of Huda*et al.* (2007) and Cicek *et al.* (2010). The present study also confirmed the results of Jin *et al*. (2005) who reported that P application increases total root length and average root diameter of *Glycine max*. In most species, P-deficiency results in decreased average root diameter (Hill *et al.*, 2006) however, some species, such as *Arabidopsis thaliana*, develop larger roots in P-deficient conditions (Ma *et al.*, 2001).

Conclusion

The efforts to ensure successful biodiversity regeneration and conservation of our indigenous, priority and threatened tropical forest tree species start from overcoming challenges confronting their seed germination and seedling growth at nursery stage. To meet population demand of the potentials of *V. paradoxa* tree, seedling growth of it need to be improved by predisposing it to appropriate leaf litters of nitrogen fixing trees, which are cheap source of adoptable, adaptable, accessible and environmentally friendly nutrients that help to restore and maintain soil fertility for sustainable crop productivity. Investigation conducted into growth response of *V. paradoxa* to leaf litters of selected nitrogen fixing trees revealed that planting of *V. paradoxa* seedlings in the soil mixed with *A. leucophloea* leaf litters enhanced its growth to meet population demand as well as to increase the biodiversity conservation.

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